Micro-contaminations of Copper and Silver on Silicon Wafer Surfaces

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Metallic contamination represents one of the major causes for low yields and poor performance of semiconductor devices. Several types of metals are found to contaminate wafer surfaces by plating out from dilute hydrofluoric acid solutions. Copper contamination has been most commonly studied due to its wide presence in IC fabrications, however, contaminations from metals other than copper such as silver, iron and nickel can often occur simultaneously. It is, therefore, important to identify multiple metallic contaminations and to understand their behaviors.

In this work, micro-contaminations of copper and silver on n-type silicon were investigated by performing a series of electrochemical polarization measurements in 5% hydrofluoric acids and ethanol solutions. The solutions used in the experiments were either without adding contaminants or by adding various concentrations of copper and/or silver which were intentionally contaminated by standard Cu^{2+} and Ag^{+} solutions. The surface morphologies of metallically contaminated wafers were characterized by scanning electron microscopy to probe the nature of copper and silver micro-contaminations.

The polarization results on n-type silicon revealed that the open-circuit potentials shifted to a more anodic direction and the corrosion rates of silicon significantly increased when either copper or silver was present in solutions, in particular, when both contaminants were intentionally introduced into solutions. The polarization resistance, which is an inverse of electrochemical reaction rate, rapidly dropped as an increase of contaminant concentrations, indicating an accelerated reaction at the silicon/solution interface. Surface morphologies of copper and silver contaminated wafers clearly showed the deposited nanometer-size metallic crystallites. It appears that both copper and silver were readily deposited on wafer surfaces. When both copper and silver were present, the nanometer-sized crystallites tended to be coagulated each other. As the concentration of copper and silver increased, the amount of metallic crystallites remarkably increased, and this led to the enhancement of metallic deposition and rougher surfaces. Possible mechanism of copper and silver micro-contaminations on n-type silicon surfaces is discussed in detail based on the experimental results.

Acknowledgement

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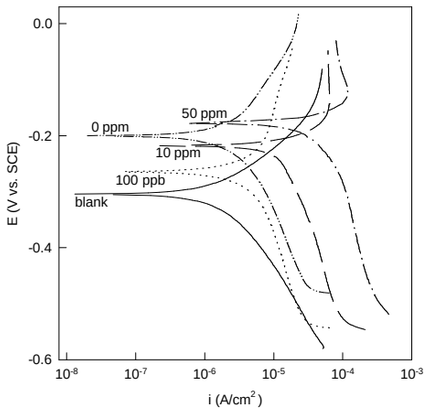

Fig. 1 Polarization curves of n-type silicon in 5% HF+EtOH solutions containing 100 ppb silver with variation of copper concentrations indicated on each curve

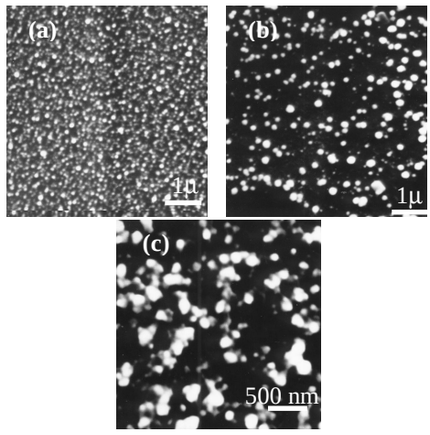

Fig. 2 Surface morphologies of n-type silicon contaminated in 5% HF+EtOH solutions containing (a) 100 ppm silver (b) 1 ppm copper and 10 ppm silver (c) 10 ppm copper and 1 ppm silver